CEWES MSRC/PET TR/97-01

A Taxonomy of Major CTA Software at CEWES MSRC

by

Steve Bova
Wayne Mastin
Carey Cox

DoD HPC Modernization Program
Programming Environment and Training
CEWES MSRC

Work funded by the DoD High Performance Computing
Modernization Program CEWES
Major Shared Resource Center through

Programming Environment and Training (PET)

Supported by Contract Number: DAHC 94-96-C0002
Nichols Research Corporation

A Taxonomy of Major CTA Software at CEWES MSRC

Steve Bova*
Wayne Mastin†
Carey Cox‡

March 13, 1998

*CEWES On-site CFD Lead for PET, Mississippi State University
†CEWES Academic Coordinator for PET, Nichols Research
‡CEWES CTA Specialist, Nichols Research

Contents

1 Introduction

The subject of this study is the set of applications categorized under the CFD, CSM, CWO, and EQM CTA's which was run on the Cray C916 and YMP at the Corps of Engineers Waterways Experiment Station Major Shared Resource Center during the last six months of 1996. These particular CTA's were chosen because they will have on-site specialists to provide support for CEWES users. The objectives are to identify the users who consume the most computational resources, determine basic features of their software, and obtain a flavor of their associated physical applications.

The metric used to determine if an application is resource-intensive is the product of memory words and CPU hours. This metric is preferred over simple CPU hours because it is biased towards codes which require large amounts of memory, and will therefore be more immediately affected by the transition to distributed memory architectures such as the Cray T3E or IBM SP2. The codes which are large in this sense will require the use of several processors on these machines if they need more memory than that which is available on a single processor.

The data for this analysis were generated from the command summaries provided by the Cray system software by calculating the metric for each process within each CTA, accumulating over the six month period, and sorting the resulting totals by user ID. This procedure was performed using the combined command summaries for the YMP and C916, as opposed to using each summary separately. This information was then merged with data obtained from the Remedy database, which provides the users' location, contact information, employment affiliation (government, university, or industry), and in many cases project descriptions. Finally, users were contacted individually in order to obtain details on the internal algorithms of their software. For example, do they use structured grids? Do they require any particular library for a matrix solver?

Table 1 gives the breakdown of Megaword-hours (Mw-hours) by CTA. Clearly CFD and CSM presently consume the lion's share of Cray resources. It is interesting to note that

CTA	CSM	CFD	SIP	CCM	CWO	CEA	EQM	OTHER	CEN
Usage	1,700	1,560	545	372	110	68.4	61.9	47.3	0.480

Table 1: Breakdown of Cray usage in thousands of Megaword-hours by CTA

although a significant fraction of the total Mw-hours was billed under SIP, there were only four users, and over 99% of the total was charged to a single user.

Table 2 presents the breakdown of Cray usage by ACID. There were a total of 27 different ACIDS, but only ten of the ACID'S consumed over 90% of the total 4.47 million Mw-hours. Thirteen ACID's consumed less than 1.0% of the total. Thirty seven per cent of the total was billed to CEWES, 13% to NRLSS, 7% to WRITEW, and less than six per cent to each of the remaining ones.

We remark that this report may present an incomplete picture of the needs of MSRC users. For example, some users may perform their calculations on other CEWES machines instead of the Crays (*e.g.* the SGI Power Challenge Array or large workstations); software which is not run on the CEWES Crays is excluded from this analysis.

In the remainder of this report, the major users within each of the four CTA's of interest are identified and their codes are briefly described. The CFD CTA is discussed in Section 2, CSM in Section 3, CWO in Section 4, and EQM in Section 5. For CFD and CWO, there are almost as many different codes as users, with very few codes being run by more than one user. Hence the code descriptions are indexed by the user. On the other hand, CSM and EQM software consists of a relatively small set of codes that are run by many users. In this

ACID	Mw-hours	% of total	Cumulative %
CEWES	1671699	37.4	37.4
NRLSS	557579	12.6	49.9
WRITW	309391	6.93	56.8
NSWCC	260797	5.84	62.6
DSWAA	245995	5.51	68.2
AFOSR	243475	5.45	73.6
PHILK	235719	5.28	78.9
ARLAP	194247	4.35	83.3
ONRDC	193320	4.33	87.6
NRLDC	189052	4.23	91.8
OUSAF	87168	1.95	93.8
WRITE	58305	1.31	95.1
MICOM	47549	1.06	96.2
NRLMR	45384	1.02	97.2
PHILE	32567	0.729	97.9
ARONC	26922	0.603	98.5
NCCOS	20411	0.457	99.0
NSWCD	16624	0.372	99.3
NUWCN	8284	0.186	99.5
PHILH	6572	0.147	99.7
NVDVA	5938	0.133	99.8
DARPA	3189	0.0714	99.9
ATCOM	3008	0.0674	99.9
NAWCC	1753	0.0393	100
NAWCP	899	0.0201	100
ARMSB	52	0.0012	100
TARDE	7	0.0002	100

Table 2: Breakdown of Cray usage by ACID

latter case, it seems more natural to separate the code descriptions from the user profiles. Finally, an Appendix is given, in which user project and contact information is presented for each CTA.

2 CFD Usage

2.1 User Profile

There were 112 unique CFD users during the second half of 1996. In order to obtain a more manageable number for this study, we restricted our interest to the top twenty-two users which together accounted for 75.5% of the total CFD Mw-hours. Each individual user in this group consumed no less than 1.4% of the total, and the largest user spent 15.7% of the total. This group of users is listed in Table 3 in descending order. Of the twenty-two users listed in Table 3, ten are employed by commercial companies, six are graduate or post-doctoral students, and the remaining six are government employees.

Location	User Name	ACID	Primary Codes	Mw-hr	% of total
SAIC	J. Baum	DSWAA	flo97, flo98	245,782	15.7
Boeing	J. Wai	PHILK	overflow	117,256	7.5
U of AZ	S. Wernz	AFOSR	lwj3d, nst3d	87,356	5.6
WPAFB	P. Cali	WRITW	f22, pegasus	74,439	4.8
Logicon	A. Lampson	PHILK	Mint_6.5	58,530	3.7
MDA	D. Fricker	AFOSR	ULTRA, msfens	57,834	3.7
Aero Corp	J. Wang	OUSAF	srm	53,190	3.4
NSWCC	J. Gorski	NSWCC	dtns	47,808	3.1
CRAFT	N. Tonello	ARLAP	CRAFT	40,046	2.6
WPAFB	S. Cox-Stouffer	WRITW	GASP	39,467	2.5
UCLA	G. Furumoto	AFOSR	a.out	36,951	2.4
U of VT	X. Wu	ONRDC	a.out, try0386	36,167	2.3
U of AZ	D. Troubier	ARLAP	nsaswk, sswake	35,237	2.3
CRAFT	B. York	NSWCD	CRAFT	34,695	2.2
NRLDC	F. Grinstein	NRLDC	a.out	32,257	2.1
CRAFT	D. Kenzakowski	MICOM	CRAFT	29,055	1.9
PSU	C. Hsiao	ONRDC	3dgen, ins3d	28,268	1.8
WRITE	L. Lijewski	WRITE	BegMR	27,752	1.8
NRAI	R. Robins	NSWCC	ir3d	26,103	1.7
UIUC	T. Madden	PHILK	GASP	25,133	1.6
Rockwell	C. Woan	PHILK	overflow, cfl3d	23,808	1.5
ARLAP	H. Edge	ARLAP	f3d96	23,142	1.5

Table 3: The top CFD users

2.2 Code Descriptions

This section presents details on the group of users presented in Table 3. For each user, their name, affiliation, and a brief description of their software and project is given.

J. Baum is an employee of Science Applications International Corp. (SAIC) in McLean, Virginia. He runs two processes, flo97 and flo98. These two codes are different versions of an unstructured finite element blast wave model developed with R. Löhner of George

Mason University. These codes can operate in both explicit and implicit modes, and have a self-contained GMRES solver for the nonsymmetric linear systems. In general, the codes are used for both basic research and specific applications for DSWAA. He indicated that at present, they are not very interested in the T3E, but would like access to a large ($\sim$ 20 GB) SGI O2000. They have a shared-memory version which already runs on a sixteen processor O2000.

J.C. Wai is an employee of Boeing Defense and Space Group in Seattle. He runs the NASA Ames code OVERFLOW on a single processor at CEWES, although there is a PVM version which runs on the SP2. It is a Chimera grid code with an iterative implicit solver. His area of application is the development of a next-generation Navy fighter, and Bob Walters is the P.I.

S. Wernzs is a graduate student at the University of Arizona in the Department of Aerospace and Mechanical Engineering. His supervisor is Herman Fasel. He runs two codes, lwj3d and nst3d, which are pseudodspectral, incompressible 3D Navier-Stokes models used for large-eddy simulation. He performs basic research regarding wall jet geometries, funded by the Air Force whose long-term interest is in propulsion applications. They use implicit solvers.

P. Cali is a government employee of Wright-Patterson AFB in Ohio. Unfortunately, he is on TDY in Europe until September and was therefore unavailble for this survey. He runs f22 and pegasus.

A. Lampson is an employee of Logicon R.&D. Associates in Albuquerque, New Mexico. He runs a single process, Mint_6.5. It is a steady-state, finite difference, structured grid ADI code with a direct implicit solver. The project involves chemical oxygen-iodine laser research modelled by the compressible, 3D, chemically reacting Navier-Stokes equations. Mint is the property of SAIC, but for historical reasons the government is allowed free use. There is no parallel work under way at present, but it is under consideration.

D. Fricker works for McDonnell Douglas Aerospace in Huntington Beach, California. He runs two primary codes, ULTRA and MSFENS. MSFENS is an unstructured "next-generation" code that was written by David Marcum of Mississippi State University. Fricker's project involves the investigation of different methods for solid rocket motor separation. The numerical model of ULTRA is 3D, transient, compressible, Navier-Stokes on structured or Chimera grids. He currently uses explicit methods but wants to move to implicit.

J.C.T. Wang works at The Aerospace Corporation in Los Angeles. His primary process is srm, a finite volume, total variation diminishing, unsteady, compressible Navier-Stokes code. It can be run in either implicit or explicit mode. It uses Gauss-Sidel relaxation with block-tridiagonal solvers. it is a multibody code that can be run in parallel with domain decomposition. His project involves the study of buffeting flow over the fairings of the Titan IV solid rocket motor launch vehicle.

J. Gorski is a government employee at the Naval Surface Warfare Center Carderock in Bethesda. He runs the process dtns3d, a 3D finite volume, Reynolds-averaged Navier-Stokes model. This is a Navy code that has a self-contained ADI solver. His project involves mostly steady (some unsteady) flows around ships and submarines using very large block-structured grids. He is interested in parallel processing, but is not currently funded in that direction. He wants to move to the UNCLE code, written by David

Whitfield at Mississippi State University. If it turns out that UNCLE has all the required functionality, then it will replace dtns3d.

N. Tonello is an employee of Combustion Research and Flow Technology, Inc. which is located in Dublin, PA. He runs various versions of CRAFT. This code is a three-dimensional, compressible, chemically reacting Navier-Stokes ADI code which uses a finite volume discretization on structured grids. Sometimes they use LAPACK to solve the systems if the block size exceeds the capabilities of their block-tridiagonal solver. The several versions have different chemical and multiphase models. The code is the property of Combustion Research, Inc., but was developed largely with government money. Hence it is believed that at least one federal agency may have free use. They are considering a parallel version for the T3E, and have a prototype which runs on an IBM SP2.

S. Cox-Stouffer is an employee of Taitech Inc. and runs GASP. This is a commercial, unsteady 3D turbulent compressible Navier-Stokes code with multigrid and chemistry capabilities. A shared-memory version exists.

G. Furumoto is a Mechanical and Aerospace Engineering graduate student at UCLA. His project is basic research into low density 3D hypersonic flows using a structured-grid finite difference/finite volume code that uses both LU decomposition and Gauss-Siedel line relaxation. The PI is Xiaolin Zhong.

X. Wu is a post-doc at the University of Vermont in the Mechanical Engineering Department. He is working on large-eddy simulations.

D. Trourbier is a graduate student at the University of Arizona in the Aerospace and Mechanical Engineering department. He works with Herman Fasel's group (see **S. Wernz**, above) and runs the processes nsaswk and sswake.

B. York is an employee of Combustion Research and Flow Technology, Inc. He runs various versions of CRAFT. (See **N. Tonello**, above.)

F. Grinstein is a government employee at Naval Research Laboratory in Washington, D.C. His project involves large eddy simulations of the dynamics of non-circular jets. His code is an explicit, structured, second order Runge-Kutta algorithm for solving the compressible, subsonic, 3D, chemically reacting Navier-Stokes equations. He has run his code in parallel on 16 processors of our C90 and is looking forward to developing a version for the T3E.

D. Kenzakowski is an employee of Combustion Research and Flow Technology, Inc. He runs various versions of CRAFT. (See **N. Tonello**, above.)

C. Hsiao is a post-doctoral student in the Mechanical Engineering department at Penn State University. He runs the process ins3d.

L. Lijewski is a government employee at Wright Laboratory at Eglin. He runs the process BegMR which was written by Dave Belk, who is also at Eglin. This code is a compressible Euler/Navier-Stokes equation solver that uses either a Chimera or a non-overlapping, block-to-block method to simulate weapons carriage and separation. The code is implicit with an iterative matrix solver.

R. Robins is an employee of Northwest Research Associates Inc. in Bellevue, WA. He runs the process ir3d to study fundamental hydrodynamics features arising from the motion of underwater vehicles. This code is an incompressible, time-accurate, 3D oceanographic Navier-Stokes solver. This explicit code is commercial property, but was custom-written by him for this application. The public domain library LAPACK is needed, and the code uses fast Fourier transforms on a structured grid.

T. Madden is a graduate student in Aerospace Engineering at The University of Illinois at Urbana-Champaign. He runs GASP.

C.J. Woan is an employee of Rockwell International. He runs the NASA Ames code OVERFLOW (see **J. Wai**, above). He was involved with an airborn laser aerodynamics design project under the direction of Capt. K. Miller, but his role in that project has since terminated.

H. Edge is a government employee at Aberdeen Proving Ground, MD. He runs the process f3d96, an implicit, structured Chimera grid code. The project is currently simulating the movement of fins, with the goal to simulate the motion of more general control surfaces such as canards. An MPI version of this code is currently under development via CHSSI.

3 CSM Usage

The top users in the CSM CTA are listed in Table 4. The individuals listed in this Table include all users consuming more than 1,000 Mw-hours and account for over 99 percent of all resources consumed under the CSM CTA. Approximately 88 percent of the total Mw-hours was consumed by the top two users which are both at CEWES. Their work will be continuing as a part of the DoD Challenge Project "Khobar Towers Bomb Damage Studies".

3.1 User Profile

Most users in the CSM CTA are located at DoD laboratories. CEWES and the Naval Surface Warfare Center - Carderock (NSWCC) are about equally represented in the list of top users in Table 4. There are also three users at ARL. The users which are not at DoD labs are James Britt who is a CEWES contractor located at the SIAC office in St. Joseph, Louisiana and Rembert Jones who is a staff member of the Computational Solid Mechanics Laboratory at SUNY - Stoney Brook. Of the CEWES users, all are located in the Structures Laboratory except for David Horner and Michael Hammons who are in the Geotechnical Laboratory. Peter King has left CEWES since this data was collected and his efforts will be assumed by others in the Structures Laboratory.

3.2 Code Descriptions

For the most part, codes run under the CSM CTA are large codes developed by industrial or govenment laboratories. They generally have several hundred thousand lines of Fortran and their own (sometimes limited) preprocessing and postprocessing. The one exception in Table 4 is the PLOW discrete element codes developed at CEWES. These are particle codes for the analysis of large deformation problems in soil mechanics. The codes are relatively small, consisting of less than 10,000 lines of Fortran. The version being run on the C916 uses autotasking. A parallel MPI version is also available at CEWES.

A brief description will be given for each code listed in Table 4.

CTH An Eulerian finite difference code developed by Sandia Laboratories for the solution of shock physics problems. A cartesian grid with variable spacing and multiblock capability can be implemented. Source code is available at CEWES. Most applications at CEWES have used the Cray microtask version MICROCTH. A parallel version of CTH (PCTH) has been developed by Sandia Laboratories.

EPIC A Lagrangian finite element code originally developed under government contract by Honeywell. The code is currently distributed by Alliant Techsystems, Inc. and is freely available for government use. EPIC is primarily used for projectile penetration analysis. There does not appear to be any efforts to parallelize EPIC.

CSA/NASTRAN A commercial version of the NASTRAN finite element analysis code marketed by Computerized Structural Analysis Research Corporation. It is primarily for the solution of small deformation problems. Capabilities include design analysis and optimization and acoustic modeling.

PLOW This is a collection of particle codes for the analysis of large deformation problems in soil mechanics. The codes are relatively small, consisting of less than 10,000 lines of Fortran. The version being run on the C916 uses autotasking and requires between 12 and 25 Mws. A parallel MPI version is also available at CEWES. These codes were developed at CEWES under the direction of Dr. John Peters of the Geotechnical Laboratory.

RAGE An Eulerian finite difference hydrocode developed by SIAC with DNA funding. The code is now supported by Los Alamos National Laboratory. A Godunov scheme is used in the solver. RAGE is primarily for modeling water shock problems with radiation effects. A parallelized version is available, but has not been used at CEWES.

DYNA3D A finite element structural dynamics code developed by Lawrence Livermore National Laboratory. It is used for large deformation problems. A parallel version (PARADYNE) using MPI is available.

SARA2D/3D These are two and three-dimensional finite element acoustic simulation codes. They were developed by BBN Incorporated of Boston, MA under a contract with ONR. Both codes reportedly have parallel solvers which are not being used on the C916.

ABAQUS A commercial finite element analysis code marketed by Hibbitt, Karlsson and Sorensen, Inc.

4 CWO Usage

4.1 User Profiles

The CWO users make up a diverse group located in all areas of the country. Of the 15 top users listed in Table 5, six are from CEWES and all of these are government employees in the Coastal and Hydraulics Laboratory. Total CEWES usage accounts for approximately 20% of the CWO work.

4.2 Code Descriptions

This section presents details on the users contained in Table 5. Several of the CEWES users are grouped together since they are involved in the same projects and use the same code.

Location	User Name	ACID	Primary Codes	Mw-hr	% of total
CEWES	T. Bevins	CEWES	CTH	1,148,847	67.7
CEWES	P. King	CEWES	CTH, EPIC	343,133	20.2
NSWCC	R. Cheng	NSWCC	CSA/NASTRAN	41,373	2.4
NSWCC	S. Hambric	NSWCC	CSA/NASTRAN	40,353	2.4
NSWCC	G. Everstine	NSWCC	CSA/NASTRAN	39,773	2.3
CEWES	D. Horner	CEWES	PLOW	14,126	0.8
NSWCC	R. Miller	NSWCC	CSA/NASTRAN	13,794	0.8
SIAC	J. Britt	CEWES	RAGE	9,082	0.5
NSWCC	A. Quezon	NSWCC	CSA/NASTRAN	7,771	0.5
CEWES	S. Garner	CEWES	DYNA3D	7,589	0.4
NSWCC	R. Vasudevan	NSWCC	SARA2D/3D	5,611	0.3
SUNY	R. Jones	NSWCC	ABAQUS	3,159	0.2
ARL	M. Raftenberg	ARL	EPIC	3,120	0.2
ARL	G. Gazonas	ARL	DYNA3D	2,742	0.2
CEWES	J. Baylot	CEWES	DYNA3D	2,698	0.2
NSWCC	C. Dann	NSWCC	SARA2D/3D	2,259	0.1
ARL	D. Hopkins	ARL	DYNA3D	1,850	0.1
CEWES	M. Hammons	CEWES	ABAQUS	1,784	0.1
CEWES	P. Papados	CEWES	DYNA3D	1,651	0.1
NSWCC	L. Chrysostom	NSWCC	ABAQUS	1,233	0.1
NSWCC	M. Leibolt	NSWCC	SARA2D	1,130	0.1

Table 4: The top CSM users

J. Ridout is a government employee of the Naval Research Laboratory at Monterey. His primary code is the Navy Operational Regional Atmospheric Prediction System (NOGAPS). This is an atmospheric prediction model developed by the Navy. The current version of the code runs on six processors, and there is an effort at NRL to write a distributed memory version.

H. Wang is a government employee of the Coastal and Hydraulics Laboratory at CEWES. His primary code is CH3D, which is a CHSSI code. CH3D is a 3D, structured grid, ADI, finite difference free surface model. It solves the flow equations in curvilinear coordinates.

H.S. Kang is a graduate student at the University of Miami working on an ONR grant monitored by Manuel Fiadeiro. He works at the Ocean Prediction Experimental Laboratory (OPEL). His supervisor at OPEL is Christopher N. K. Mooers. OPEL uses ocean modeling codes developed at the lab and the Princeton Ocean Model (POM) developed by Princeton University. POM is a free surface, primitive equation ocean model, which includes a turbulence submodel. It is used for modeling of estuaries, coastal regions and open oceans.

P. Posey is a government employee of the Naval Research Laboratory at Stennis Space Center. In the past, she ran pips2_c on four processors. She does not plan to be a big user of CEWES computers in the future.

D. DeBenedictis is employed by Sencom Corporation and is located at Phillips Laboratory Geophysics Directorate, Hanscom AFB, MA. He is running a mesoscale atmospheric model mm5 developed and supported by NCAR.

F.G. Jacobitz is a graduate student in the Department of Applied Mechanics and Engineering Sciences at the University of California, San Diego working on an ONR grant monitored by Manuel Fiadeiro. He is developing a spectral collocation CFD code for modeling turbulent flow.

T.N. Krishnamurti is a Professor of Meteorology at Florida State University working on ONR grants monitored by Manuel Fiadeiro.

W.A. Brandon, R. M. Brooks, L. Lin, and S. McGee-Rosser are government employees of the Coastal and Hydraulics Laboratory at CEWES. All are working with WISWAV, a 3D, finite difference, spherical coordinate, wave propagation model. It takes wind information as input and computes wave heights, periods and directions. It is a serial code.

J. Wang is a Senior Research Scientist at the University of Miami working on an ONR grant monitored by Manuel Fiadeiro. He works at the Ocean Prediction Experimental Laboratory (OPEL).

J. Lopez is a graduate student at the Colorado Center for Astrodynamics Research, University of Colorado, Boulder. His supervisor is Lakshmi H. Kantha, a Professor in the Department of Aerospace Engineering Sciences. He is running the ocean modeling code Gtd2d and using 16 processors on the C90.

R. Mowrey is a government employee of the Naval Research Laboratory at Washington, DC. He runs his own user-developed codes which model the chemical reaction of hydrogen atoms on a metal plate. His codes use vector-matrix multiplies and multidimensional FFTs. Both of these operations can be parallelized, although he has not initiated an effort in parallelizing his codes.

S. Bratos is a government employee of the Coastal and Hydraulics Laboratory at CEWES. He uses WAM, a 3D, finite difference, structured grid, expicit, wave amplitude model, which uses multi-gridding to resolve complex geometry and localized phenoma, i.e., coastlines and storms. This is a CHSSI code and is being parallelized.

5 EQM Usage

5.1 User Profile

There were 20 EQM users during the second half of 1996, seventeen of which are located at CEWES. All of the EQM users are government employees. The top 9 users accounted for over 93% of the approximately 61,900 total Mw-hours charged to this CTA. These users are presented in Table 6, and each consumed at least 2% of the EQM total. The largest single user was W. Boyt, who was charged with 34% of the total EQM Mw-hours.

5.2 Code Descriptions

RMA10 is a 3D, unstructured, time-accurate finite element hydrodynamic free surface model written by Ian King. It includes models for salt and sediment transport, and uses a Newton method with a direct solver for the linear subsystems.

CH3D is a 3D, structured grid, ADI, finite difference free surface model. A shared memory version of this code exists and an MPI version is under development.

Location	User Name	ACID	Primary Codes	Mw-hr	% of total
NRL-Monterey	James Ridout	NRLMR	NORAPS	44,731	40.6
CEWES	Harry Wang	CEWES	ch3d	14,135	12.8
U of Miami	Hee Sook Kang	ONRDC	POM	10,496	9.5
NRL-Stennis	Pamela Posey	NRLSS	pips2_c	6,332	5.7
Sencom Corp.	Daniel DeBenedictis	PHILH	mm5	6,296	5.7
UC - San Diego	Frank G. Jacobitz	ONRDC	cftsq	6,077	5.5
FSU	T. N. Krishnamurti	ONRDC	a.out	2,748	2.5
CEWES	Willie A. Brandon	CEWES	WISWAV	2,605	2.4
CEWES	Rebecca M. Brooks	CEWES	WISWAV	2,451	2.2
U of Miami	Jia Wang	ONRDC	POM	2,110	1.9
U of Colorado	Joseph Lopez	ONRDC	Gtd2d	1,843	1.7
NRL-DC	Richard Mowrey	NRLDC	wpvib22g	1,441	1.3
CEWES	Lihwa Lin	CEWES	WISWAV	1,263	1.1
CEWES	Sheila McGee-Rosser	CEWES	WISWAV	1,085	1.0
CEWES	Steve Bratos	CEWES	WAM	1,070	1.0

Table 5: The top CWO users

Location	User Name	ACID	Primary Codes	Mw-hr	% of total
CEWES	W. Boyt	CEWES	RMA10	21,120	34.1
CEWES	K. Kim	CEWES	CH3D	10,373	16.7
CEWES	G. Brown	CEWES	RMA10	5,952	9.6
CEWES	A. Raman	CEWES	RMA10	5,859	9.5
CEWES	L. Roig	CEWES	RMA10, RMA2	4,693	7.6
CEWES	S. Martin	CEWES	sigseddm, RMA10	4,365	7.0
CEWES	B. Bunch	CEWES	CH3D,CEQUAL	2,922	4.7
CEWES	J. Pettway	CEWES	r4v430	1,305	2.1
CEWES	F. Herrman	CEWES	CEQUAL	1,248	2.0

Table 6: The top EQM users

RMA2 is a two-dimensional ancestor of RMA10 without salt or sediment transport. The fundamental algorithms are the same as RMA10.

sigseddm is a 3D, structured grid finite-difference hydrodynamics code. It is a version of CH3D with sediment transport added.

CEQUAL is a multiconstituent water quality model with biological components. It is a finite volume code that uses structured grids and takes velocity input data from CH3D.

r4v430 (RMA4) is another two-dimensional ancestor of RMA10. It is a companion code to RMA2 that models salt/sediment transport without the hydrodynamics. The fundamental algorithms are the same as RMA10.

Acknowledgment

The authors wish to thank Philip Williams and Theresa Lee for their assistance in extracting data from the Remedy database.